ES.0 EXECUTIVE SUMMARY

The Mexico National Emissions Inventory (NEI) is the culmination of many years of hard work and partnership between Mexico's Secretariat of the Environment and Natural Resources *(Secretaría de Medio Ambiente y Recursos Naturales—SEMARNAT)* and National Institute of Ecology *(Instituto Nacional de Ecología—INE)*, the U.S. Environmental Protection Agency (U.S. EPA), Western Governors' Association (WGA), and the North American Commission for Environmental Cooperation (CEC). Representatives from these partners, along with other stakeholders from government, academia, and the private sector, participated in the Technical Advisory Committee (TAC) and provided technical guidance for development of the Mexico NEI.

The Mexico Emissions Inventory Program began in 1995 with a vision to increase capacity within Mexico for development of emission inventories and focused on the development and implementation of the methodology manuals and training. In 2001, the focus expanded to include the development of the Mexico NEI in three phases:

- Phase I: Planning and methodology development;
- Phase II: NEI for the six northern states; and
- Phase III: NEI for the entire country (32 states).

This report describes the scope, approach, and results of the completion of Phase III – the inventory of criteria and visibility pollutants for the entire country of Mexico at the municipality level for the year 1999.

ES.1 Mexico NEI Objectives and Scope

The objectives of the Mexico NEI were identified by the TAC as follows:

- Comply with the Mexican Federal Environment Law mandate to integrate and update a National Emissions Inventory for Mexico;
- Promote Mexican institutional capacity-building to compile, maintain, and update emissions inventories;
- Provide a technical basis for improved air quality and health impact analyses in Mexico and the U.S.;

- Assist with regional haze requirements in the U.S.; and
- Support the development of a tri-national emissions inventory of criteria pollutants for Mexico, the U.S., and Canada.

Some specific end uses for the Mexico NEI are to provide the technical data needed for national-level analyses of air emission sources affecting air quality and public health in Mexico, and to provide the input data needed to conduct air quality modeling of criteria and visibility pollutants.

The scope of the Mexico NEI is defined by its geographic domain, base year, pollutants, and source types. The geographic domain is the country of Mexico (Figure ES-1). The base year of 1999 was chosen because most governmental agencies possessed complete sets of the types of data needed to estimate emissions for that year. Also, the year of 1999 corresponds with U.S. EPA's National Emissions Inventory triennial reporting cycle.

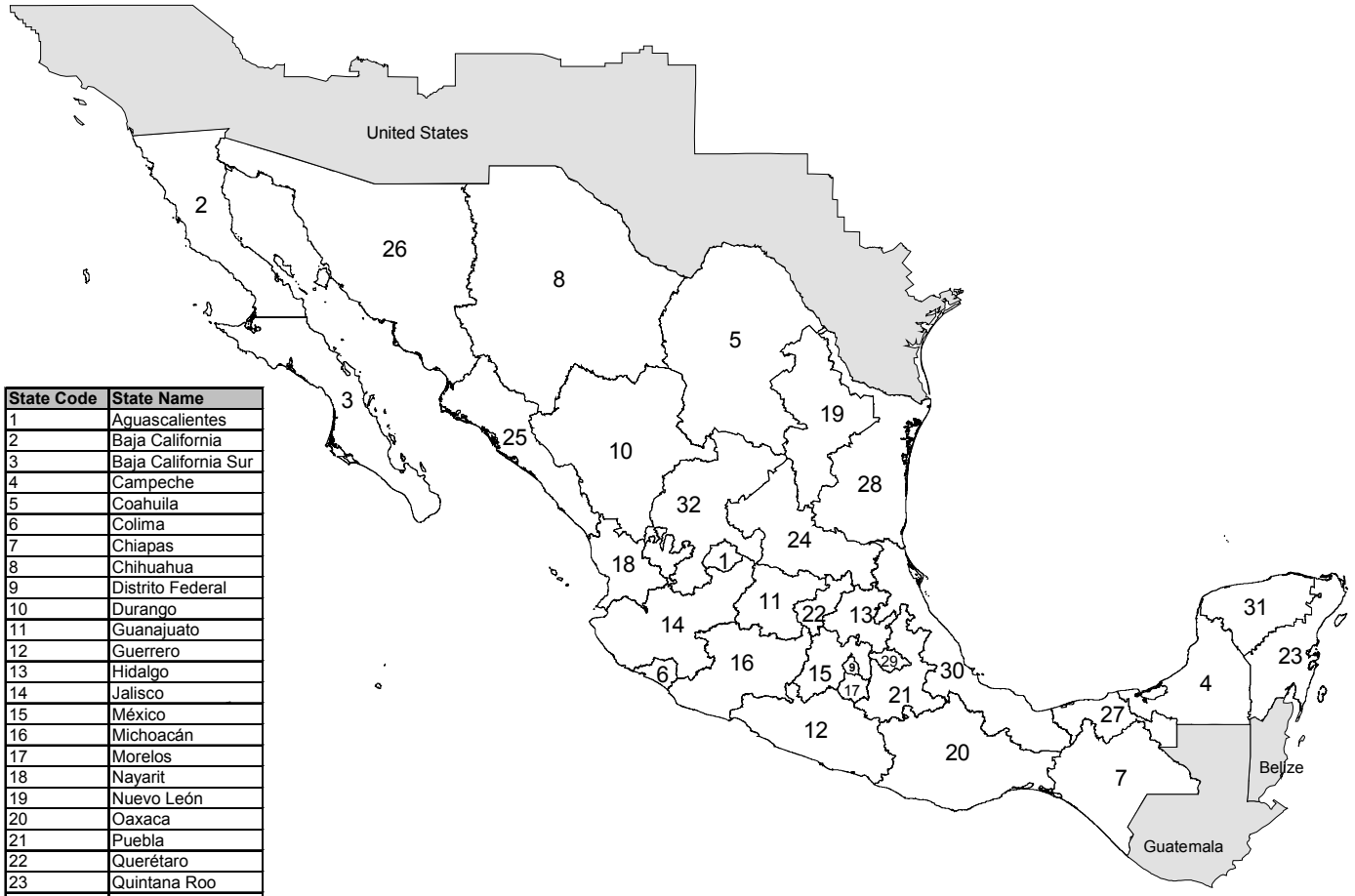
The pollutants for the Mexico NEI include the air pollutants, or their precursors, for which Mexico has air quality standards: nitrogen oxides (NO_x), sulfur oxides (SO_x), volatile organic compounds (VOC), carbon monoxide (CO), and particulate matter (PM) smaller than 10 micrometers (μm) in aerodynamic diameter (PM_{10}). Also, the Mexico NEI includes estimates of PM smaller than 2.5 μm in aerodynamic diameter ($PM_{2.5}$ – a visibility pollutant) and ammonia (NH_3 – a potential precursor to visibility species). The source types include all anthropogenic sources as well as natural (i.e., biogenic and geogenic) sources of air pollution.

ES.2 Discussion of Results

Summaries of the 1999 Mexico NEI for the entire country are shown in the following tables:

- Table ES-1 (by source category and pollutant);
- Table ES-2 (by state and pollutant); and
- Table ES-3 (by state and pollutant as a percentage of total annual pollutant emissions).

Figure ES-1. The Country of Mexico



State Code	State Name
1	Aguascalientes
2	Baja California
3	Baja California Sur
4	Campeche
5	Coahuila
6	Colima
7	Chiapas
8	Chihuahua
9	Distrito Federal
10	Durango
11	Guanajuato
12	Guerrero
13	Hidalgo
14	Jalisco
15	México
16	Michoacán
17	Morelos
18	Nayarit
19	Nuevo León
20	Oaxaca
21	Puebla
22	Querétaro
23	Quintana Roo
24	San Luis Potosi
25	Sinaloa
26	Sonora
27	Tabasco
28	Tamaulipas
29	Tlaxcala
30	Veracruz
31	Yucatán
32	Zacatecas

Table ES-1. 1999 Mexico National Emissions Inventory - Summary by Source Category and Pollutant

Source Category	Emissions (Mg/year)						
	NO_x	SO_x	VOC	CO	PM_{10}	$PM_{2.5}$	NH_3
Mining	30,323.7	147,108.2	27,977.6	45,983.7	32,427.6	15,538.0	
Utilities – Electricity Generation	259,833.8	1,604,849.2	11,394.4	25,310.8	79,508.3	62,884.7	
Petroleum and Coal Products Manufacturing	39,078.3	389,056.5	55,074.0	19,765.9	18,516.8	13,043.7	
Manufacturing and Other Industrial Processes	119,537.0	492,580.8	105,981.4	76,433.7	166,802.8	107,560.5	
Other Services	50.9	276.1	80.4	8.4	20.9	14.7	
Merchant Wholesalers, Nondurable Goods	50.7	64.3	47,347.2	109.1	11.8	8.6	
Industrial Fuel Combustion	53,286.9	189,420.7	8,953.0	48,233.5	14,438.3	11,231.4	
Other Fuel Combustion	89,276.8	3,051.3	421,282.5	1,993,769.1	227,681.5	219,218.1	
Fuel Distribution			423,658.5				
Solvent Utilization			773,944.0				
Fires/Burning	9,174.4	537.5	54,943.7	402,537.2	58,689.1	53,627.7	
Fugitive Dust					127,703.9	27,279.1	
Ammonia Sources							1,297,832.5
Other Area Sources	124,582.5	1,632.2	60,805.6	56,312.2	10,740.4	9,012.9	
On-Road Motor Vehicles	435,664.7	24,452.8	573,042.4	4,671,841.8	20,567.5	18,844.9	7,609.4
Nonroad Mobile Sources	263,767.8	3,485.9	35,169.1	153,603.5	37,240.1	36,122.9	
Biogenic Sources	1,018,613.2		17,443,902.4				
Geogenic Sources		2,606,550.0			1,954,913.0	390,983.0	
Total[a]	**2,443,240.7**	**5,463,065.5**	**20,043,556.2**	**7,493,908.9**	**2,749,262.0**	**965,370.2**	**1,305,441.9**
Source Category	**Emissions (Percent)**						
	NO_x	SO_x	VOC	CO	PM_{10}	$PM_{2.5}$	NH_3
Mining	1.24	2.69	0.14	0.61	1.18	1.61	
Utilities – Electricity Generation	10.63	29.38	0.06	0.34	2.89	6.51	
Petroleum and Coal Products Manufacturing	1.60	7.12	0.27	0.26	0.67	1.35	
Manufacturing and Other Industrial Processes	4.89	9.02	0.53	1.02	6.07	11.14	
Other Services	0.00	0.01	0.00	0.00	0.00	0.00	
Merchant Wholesalers, Nondurable Goods	0.00	0.00	0.24	0.00	0.00	0.00	
Industrial Fuel Combustion	2.18	3.47	0.04	0.64	0.53	1.16	
Other Fuel Combustion	3.65	0.06	2.10	26.61	8.28	22.71	
Fuel Distribution			2.11				
Solvent Utilization			3.86				
Fires/Burning	0.38	0.01	0.27	5.37	2.13	5.56	
Fugitive Dust					4.65	2.83	
Ammonia Sources							99.42
Other Area Sources	5.10	0.03	0.30	0.75	0.39	0.93	
On-Road Motor Vehicles	17.83	0.45	2.86	62.34	0.75	1.95	0.58
Nonroad Mobile Sources	10.80	0.06	0.18	2.05	1.35	3.74	
Biogenic Sources	41.69		87.03				
Geogenic Sources		47.71			71.11	40.50	
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

[a] Total may not equal sum of category emissions due to rounding.

Table ES-2. 1999 Mexico National Emissions Inventory - Summary by State and Pollutant

State Name	Emissions (1,000 Mg/year)						
	NO_x	SO_x	VOC	CO	PM_{10}	$PM_{2.5}$	NH_3
Aguascalientes	16.38	7.06	51.30	54.85	3.56	1.89	22.92
Baja California	45.67	44.40	103.72	162.21	10.78	8.50	10.36
Baja California Sur	44.09	20.60	277.47	17.44	2.17	1.65	5.67
Campeche	64.29	151.76	1,005.34	74.44	10.81	8.04	14.65
Coahuila	219.28	175.09	441.27	147.82	31.61	29.33	26.84
Colima	25.31	192.15	96.39	27.50	12.50	8.77	6.16
Chiapas	64.88	94.13	1,304.53	380.49	50.80	39.20	93.98
Chihuahua	116.49	91.30	2,017.62	222.90	23.45	16.59	41.98
Distrito Federal	90.54	6.39	226.95	769.83	7.11	6.20	9.78
Durango	48.39	27.34	1,429.77	101.91	12.66	7.99	45.97
Guanajuato	93.84	134.05	202.82	269.78	24.13	16.78	52.62
Guerrero	72.33	191.12	1,374.74	250.90	35.06	28.11	52.28
Hidalgo	88.46	358.64	215.88	154.95	35.68	26.31	25.06
Jalísco	153.19	774.67	1,166.26	607.44	585.09	131.09	138.02
México	138.95	47.31	419.83	999.80	32.67	24.91	49.10
Michoacán	99.25	30.98	757.27	254.97	30.73	22.41	75.91
Morelos	20.81	13.86	78.89	88.76	8.32	5.55	11.97
Nayarit	21.62	2.86	483.24	54.94	7.60	4.64	23.99
Nuevo León	116.13	99.90	402.85	407.39	18.65	15.63	23.10
Oaxaca	76.11	61.82	2,149.12	332.01	45.59	35.91	61.77
Puebla	79.09	1,889.57	339.78	361.07	1,441.27	310.98	61.23
Querétaro	27.94	8.72	118.59	79.22	7.52	5.57	15.41
Quintana Roo	23.91	3.14	920.11	65.58	6.22	4.72	4.90
San Luis Potosí	65.95	85.46	317.20	180.80	25.67	18.34	34.39
Sinaloa	99.26	105.53	817.19	141.44	23.59	14.06	62.13
Sonora	97.88	159.77	842.28	148.13	41.80	23.34	49.16
Tabasco	37.23	148.84	223.23	137.54	29.22	19.31	40.84
Tamaulipas	135.99	155.27	559.19	173.52	19.68	12.20	37.51
Tlaxcala	17.42	5.63	33.17	65.71	5.34	3.83	8.34
Veracruz	161.75	342.39	650.68	547.96	129.87	93.65	124.39
Yucatán	37.96	29.83	654.28	142.94	15.15	13.00	36.37
Zacatecas	42.86	3.49	362.61	69.66	14.94	6.89	38.64
Total[a]	**2,443**	**5,463**	**20,044**	**7,494**	**2,749**	**965**	**1,305**

[a] Total may not equal sum of state emissions due to rounding.

Table ES-3. 1999 Mexico National Emissions Inventory - Summary by State and Pollutant

State Name	Percentage of Total Pollutant Emissions						
	NO_x	SO_x	VOC	CO	PM_{10}	$PM_{2.5}$	NH_3
Aguascalientes	0.67%	0.13%	0.26%	0.73%	0.13%	0.20%	1.76%
Baja California	1.87%	0.81%	0.52%	2.16%	0.39%	0.88%	0.79%
Baja California Sur	1.80%	0.38%	1.38%	0.23%	0.08%	0.17%	0.43%
Campeche	2.63%	2.78%	5.02%	0.99%	0.39%	0.83%	1.12%
Coahuila	8.98%	3.20%	2.20%	1.97%	1.15%	3.04%	2.06%
Colima	1.04%	3.52%	0.48%	0.37%	0.45%	0.91%	0.47%
Chiapas	2.66%	1.72%	6.51%	5.08%	1.85%	4.06%	7.20%
Chihuahua	4.77%	1.67%	10.07%	2.97%	0.85%	1.72%	3.22%
Distrito Federal	3.71%	0.12%	1.13%	10.27%	0.26%	0.64%	0.75%
Durango	1.98%	0.50%	7.13%	1.36%	0.46%	0.83%	3.52%
Guanajuato	3.84%	2.45%	1.01%	3.60%	0.88%	1.74%	4.03%
Guerrero	2.96%	3.50%	6.86%	3.35%	1.28%	2.91%	4.00%
Hidalgo	3.62%	6.56%	1.08%	2.07%	1.30%	2.73%	1.92%
Jalísco	6.27%	14.18%	5.82%	8.11%	21.28%	13.58%	10.57%
México	5.69%	0.87%	2.09%	13.34%	1.19%	2.58%	3.76%
Michoacán	4.06%	0.57%	3.78%	3.40%	1.12%	2.32%	5.81%
Morelos	0.85%	0.25%	0.39%	1.18%	0.30%	0.58%	0.92%
Nayarit	0.88%	0.05%	2.41%	0.73%	0.28%	0.48%	1.84%
Nuevo León	4.75%	1.83%	2.01%	5.44%	0.68%	1.62%	1.77%
Oaxaca	3.11%	1.13%	10.72%	4.43%	1.66%	3.72%	4.73%
Puebla	3.24%	34.59%	1.70%	4.82%	52.42%	32.21%	4.69%
Querétaro	1.14%	0.16%	0.59%	1.06%	0.27%	0.58%	1.18%
Quintana Roo	0.98%	0.06%	4.59%	0.88%	0.23%	0.49%	0.38%
San Luis Potosí	2.70%	1.56%	1.58%	2.41%	0.93%	1.90%	2.63%
Sinaloa	4.06%	1.93%	4.08%	1.89%	0.86%	1.46%	4.76%
Sonora	4.01%	2.92%	4.20%	1.98%	1.52%	2.42%	3.77%
Tabasco	1.52%	2.72%	1.11%	1.84%	1.06%	2.00%	3.13%
Tamaulipas	5.57%	2.84%	2.79%	2.32%	0.72%	1.26%	2.87%
Tlaxcala	0.71%	0.10%	0.17%	0.88%	0.19%	0.40%	0.64%
Veracruz	6.62%	6.27%	3.25%	7.31%	4.72%	9.70%	9.53%
Yucatán	1.55%	0.55%	3.26%	1.91%	0.55%	1.35%	2.79%
Zacatecas	1.75%	0.06%	1.81%	0.93%	0.54%	0.71%	2.96%
Total[a]	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

[a] Total may not equal sum of state emissions due to rounding.

The following observations can be made regarding these Mexico NEI summaries:

- Nearly half of the national NO_x emissions are from biogenic sources. Of the anthropogenic sources, on-road motor vehicles are the most significant contributor of NO_x, followed by nonroad mobile sources and power plants. On-road motor vehicles, power plants, and nonroad mobile sources emit approximately over 67 percent of the anthropogenic NO_x emissions (i.e., approximately 959,000 Mg/year), or approximately 39 percent of the total (i.e., anthropogenic plus natural sources) NO_x inventory.

- After geogenic/volcanic sources, power plants are the next major contributors of SO_x, followed by manufacturing and other industrial processes, petroleum and coal product manufacturing (i.e., refineries), and industrial fuel combustion (an area source). These sources emit over 93 percent of the anthropogenic SO_x emissions (i.e., approximately 2,676,000 Mg/year), or approximately 49 percent of the total (i.e., anthropogenic plus natural sources) SO_x inventory.

- Of the anthropogenic sources, solvent utilization, on-road motor vehicles, fuel distribution (i.e., gasoline and liquefied petroleum gas [LPG]), and other fuel combustion (i.e., mainly residential wood combustion) are the most significant VOC emitters. These four categories emit over 84 percent of the anthropogenic VOC emissions (i.e., approximately 2,192,000 Mg/year), or nearly 11 percent of the total (i.e., anthropogenic plus natural sources) VOC inventory.

- CO emissions are mainly from on-road motor vehicles with over 62 percent of the total CO inventory, followed by other fuel combustion (i.e., mainly LPG in the transportation sector) with approximately 27 percent of the total CO inventory.

- Geogenic/volcanic sources (i.e., the Colima and Popocatépetl volcanoes) are the most significant source of PM_{10} and $PM_{2.5}$ emissions, followed by other fuel combustion sources. Combined, these two categories contribute nearly 80 percent of the total PM_{10} and 63 percent of the total $PM_{2.5}$ emissions (i.e., 2,183,000 and 610,000 Mg/year, respectively). After geogenic/volcanic and other fuel combustion sources, the next most significant emitter of particulate emissions is manufacturing and other processes with approximately 6 percent and 11 percent of the total PM_{10} and $PM_{2.5}$ emissions, respectively.

- Livestock, fertilizer application, and domestic generation of NH_3 are responsible for the majority of the NH_3 emissions. Only very minor contributions come from on-road motor vehicles.

- Anthropogenic NO_x emissions are highest in Coahuila (i.e., mainly from power plants), Veracruz (i.e., mainly from a combination of power plants; oil and gas extraction, and refining; and, commercial marine vessels), and the Federal District (Distrito Federal – DF) and the State of México combined (i.e., mainly from on-road motor vehicles including primarily from heavy-duty diesel vehicles, with lesser amounts from light-duty gasoline vehicles and trucks).

- SO_x emissions are highest in Puebla and Jalísco (i.e., almost entirely from volcanoes), followed by Veracruz and Hidalgo. Nationally, power plants are the main contributor of anthropogenic SO_x emissions (i.e., approximately 56 percent of the total anthropogenic sources; see Table ES-1), and this is also true for Veracruz. However, in Hidalgo, refineries are the most significant SO_x emitters.

- Total VOC emissions are highest in Oaxaca, Chihuahua, Durango, Guerrero, and Chiapas (i.e., majority of emissions are from biogenic sources). Anthropogenic VOC emissions from various area and mobile sources located in the State of México, DF, Jalísco, and Veracruz are significant compared to other states. The dominant anthropogenic VOC area source categories in these states are LPG distribution and consumer solvents, with lesser quantities from degreasing and industrial surface coating.

- CO emissions are highest in the State of México, DF, Jalísco, and Veracruz. In the State of México, DF, and Jalísco, the CO emissions predominantly come from on-road motor vehicles; however, in Veracruz, the majority of CO emissions are from area sources (i.e., primarily residential wood combustion).

- Over 70% of the total national PM_{10} emissions and over 40% of the total national $PM_{2.5}$ emissions are from the volcanoes in the states of Jalísco and Puebla. The states with the greatest anthropogenic PM_{10} and $PM_{2.5}$ emissions are Veracruz, Chiapas, and Oaxaca. In Veracruz, most of the PM_{10} and $PM_{2.5}$ emissions (i.e., approximately 60% and 53%, respectively) are from point sources. In Chiapas and Oaxaca, the majority of PM_{10} and $PM_{2.5}$ emissions are from area sources (i.e., over 90% of each pollutant in Chiapas, and over 80% of each pollutant in Oaxaca).

- Livestock contributes 80 percent of Mexico's total NH_3 emissions. The four states with the greatest emissions are Jalísco, Veracruz, Chiapas, and Michoacán.

- Natural sources (i.e., biogenic and geogenic) are the most significant source of NO_x, SO_x, and VOC emissions, as well as very significant emitters of PM emissions; however, as noted in Section 7.0 of this report, there are several factors contributing to likely overestimates of biogenic NO_x and VOC emissions. Therefore, use of these emissions for purposes of modeling may not be appropriate. Furthermore, since emissions from natural sources are not controllable (i.e., as compared to emissions from anthropogenic sources), then it is not feasible to include them within an air quality plan, other than to indicate their contribution to background levels of NO_x and VOC. Also, it is important to note the location of these emission sources and their potential exposure impacts on humans. Whereas nonanthropogenic emissions for some pollutants are mostly greater (or nearly as great) in magnitude (Mg/year) as compared to the total of anthropogenic sources, the exposure impacts to humans will be greater from anthropogenic source pollutants based on their location in or near urban areas as compared to nonanthropogenic sources mostly emitting in remote or rural areas.

ES.3 Conclusions and Potential NEI Improvements

Opportunities to improve the Mexico NEI generally fall into two broad categories: improving the quality, and increasing the quantity, of data used to estimate emissions.

Point Source Opportunities

- The number of industrial facilities submitting Annual Operating Reports *(Cédulas de Ope*ración Annual – COAs) needs to be increased. Currently, SEMARNAT is making significant progress in coordinating with the state environmental agencies (SEAs) to yield better COA data from the state jurisdiction point sources. Providing SEAs with guidance on consistent reporting formats will also help to ensure data are consistent across all states, thus making the inventory process more efficient and results more accurate. Also, continued development and implementation of electronic submittal tools is recommended for improving the quality and quantity of emissions data submitted by the SEAs.

- Currently, NH_3 emissions are not recorded by facilities on their COAs. These should be included in the future to provide a comprehensive set of emissions data for air quality analyses.

- Estimates of VOC emissions from industrial facilities are not consistently estimated and reported. Developing industry-specific methods for testing and/or estimating these emissions (along with the other pollutants) would increase the quantity and quality of the emissions data.

- The majority of the point source emissions in the Mexico NEI come from power plants, oil and gas industry (i.e., refineries, oil and gas explorations, and bulk terminals), and nonmetallic minerals products industries. These sectors could be used to set priorities for development of Mexico-specific emission factors.

- Greater public access to point source emissions data can help improve data quality as knowledgeable users of the data will be able to identify and bring to the attention of the national inventory developers any discrepancies or errors in the data not previously identified through internal quality assurance efforts.

Area Source Opportunities

- Many of the area source methodologies used national-level statistics for activity data (e.g., fuel use, surface coating quantities, dry cleaning solvents, etc.). However, higher resolution activity data, such as state- or municipality-level, were typically unavailable. As a result, various spatial allocation methods were used to disaggregate the national-level activity data down to the municipality-level. These methods often relied on population or employee counts. These methods are likely to be approximations of the actual activity data distribution. Identifying and using higher resolution activity data will improve the overall quality of the area source inventory.

- Evaporative VOC sources include many different types of source categories. For some VOC categories (i.e., paint and ink statistics, dry cleaning solvent statistics), trade associations provided national-level activity data. Unfortunately, for other VOC categories (i.e., consumer solvents and degreasing), an appropriate trade association could not be identified. Consequently, U.S. default per capita or per employee emission factors were used to estimate emissions instead of Mexico-specific activity data which resulted in the VOC emissions from both consumer solvents and degreasing being relatively significant as compared to the emissions from other VOC sources. These emission estimates for degreasing and consumer solvents are highly uncertain because of the use of U.S. emission factors. Identifying and obtaining information from the appropriate trade associations will improve the accuracy of the emission estimates for these categories.

- Agricultural sources include a wide variety of fugitive dust sources (i.e., agricultural tillage and beef cattle feedlots), ammonia sources (i.e., livestock ammonia and fertilizer application), combustion sources (i.e., agricultural burning) and evaporative VOC sources (i.e., pesticide application). A key source of activity data for the agricultural sectors in general is the Secretariat of Agriculture, Livestock, Rural Development, Fisheries, and Food (Secretaría de Agricultura, Ganadería y Desarrollo Rural, Pesca y Alimentación – SAGARPA). However, the data that SAGARPA was able to provide were limited to some estimates of crop acreage and livestock population. On-going and increased interaction with SAGARPA is needed to identify and/or develop other needed agricultural activity data for use in the Mexico NEI in the future.

- Emissions from unpaved and paved road dust can be very significant sources of PM_{10} and $PM_{2.5}$ emissions. However, these were not included in the Mexico NEI since the estimation methodologies incorporate emission factor equations that require a large number of location-specific input parameters (i.e., silt loading, silt content, average vehicle speed, average vehicle weight, average silt moisture content, and number of precipitation days). With the exception of the number of precipitation days, the other relevant input parameters were only available for a few locations in Mexico (i.e., the cities of Ciudad Juárez and Chihuahua). Future development of these location-specific input parameters will enable the estimation of unpaved and paved road dust emissions.

On-Road Motor Vehicle Opportunities

- A crucial type of on-road motor vehicle activity data is vehicle kilometers traveled (VKT). Because the Mexico NEI was developed at the state- and municipality-level, VKT estimates were also developed at the state- and municipality-level. Due to limitations in other traditional sources of VKT data, the Mexico NEI used per capita emission rates developed from modeled traffic volumes and congestion levels for representative urban areas of different size. As part of the first-time development of the Mexico NEI (i.e., a national inventory with municipality-level detail), this methodology was appropriate. However, additional collection and development of travel demand models, motor vehicle fuel statistics, vehicle registration statistics, and other motor vehicle-related surveys can be used.

- On-road motor vehicle emissions were estimated using emission factors derived from the MOBILE6-Mexico emission factor model. MOBILE6-Mexico represents the most up-to-date and representative emission factor model for use in Mexico. However, there are some potential areas for improvement. The basic emission rates contained in the model are based upon fairly limited vehicle testing conducted in Mexico City, Ciudad Juárez, and Aguascalientes; additional vehicle testing would improve the quality of these basic emission rates.

- Another important type of on-road motor vehicle activity data is fleet characteristics. This includes data such as registration data, fleet age distribution, VKT mixes, etc. Some limited studies have been conducted in Mexico with the results applied throughout the country; while in other cases, U.S. data were utilized. Further studies could be used to improve the fleet characteristic information that is used to estimate on-road motor vehicle emissions.

Nonroad Mobile Source Opportunities

- Nonroad mobile sources in previous Mexican emissions inventories have been limited to aircraft, locomotives, and commercial marine vessels (included as area sources in this report). The Mexico NEI includes two additional types of nonroad mobile sources that have not been previously included in Mexican emissions inventories: agricultural equipment and construction equipment. There are, however, a number of other nonroad equipment types that are not included in the Mexico NEI (i.e., industrial/commercial equipment, recreation vehicles and boats, lawn and garden equipment, oil field and airport service support equipment, and logging equipment). Although these have been identified as being less significant source categories in U.S. emissions inventories, it is currently unclear to what extent they are important in Mexico. Future work concerning nonroad mobile sources may focus on development of activity data for these categories that are currently excluded.

- The Mexico NEI nonroad mobile source estimates used equipment populations that were either only available on the state level (i.e., for agricultural equipment) or extrapolated from U.S. data (i.e., for construction equipment). The nonroad mobile source emission estimates can be improved by obtaining Mexico-specific equipment population statistics at the local level. This will require coordination with various government agencies and/or industry associations.

- The Mexico NEI nonroad mobile source estimates also rely upon annual hours of operation that have been adjusted based upon agricultural diesel fuel use estimates from the national fuels balance. A survey of Mexico nonroad equipment operations would provide a more accurate estimate of annual hours of operation.

Natural Source Opportunities

- In the GloBEIS model, biogenic emissions are a function of meteorological data (i.e., temperature and cloud cover). To the greatest extent possible, Mexico-specific meteorological data were collected and used in the Mexico NEI. However, considerable

data gaps were found in both the temperature and cloud cover data. In order to address these data gaps, temperature and cloud cover data profiles were developed. Assumptions used in the development of these profiles potentially resulted in an overestimate of VOC emissions (i.e., increased number of clear days and higher temperatures). Emissions uncertainty can be reduced in the future if the meteorological data gaps can also be reduced.

- Biogenic emissions are also dependent upon the type of land use and land cover being considered. There are several areas of uncertainty associated with the Mexico land use and land cover data that were used in the Mexico NEI. First, actual urban areas are likely larger than what was reported in the land use data set. Also, in many cases, the data were vague and insufficiently specific with regards to detailed land use types or actual species present. This resulted in various assumptions that were made in order to run the Global Biosphere Emission and Interactions System (GloBEIS) model (e.g., several forestry species that could not be mapped to GloBEIS forestry species were assigned to "Mixed Forest"). On the other hand, the data from SAGARPA resulted in more crop types than were available in GloBEIS, so some SAGARPA crop data were mapped to a similar GloBEIS species. In the future, efforts to improve the quality of land use and land cover, mainly with regard to forestry and other non-agricultural land use types, will serve to reduce sources of uncertainty in the biogenic emission estimates.

- GloBEIS allows the user to temporally define crop cover to a high level of resolution (i.e., as fine as hourly). Unfortunately, detailed crop calendars could not be identified during the development of the Mexico NEI. This resulted in an assumption of year-round crop coverage. As a result, soil NO_x emissions likely have been overestimated in the Mexico NEI. As mentioned in Section 8.2.2, various types of agricultural activity data need to be obtained from SAGARPA in order to improve future inventories. Crop calendars are one of these types of data. If detailed crop calendars are obtained, then temporally variable crop cover can be developed for Mexico that will result in emission estimates with reduced uncertainty.